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IN-CYLINDER SAMPLING OF HYDROCARBONS IN A TEXACO L-141 TCF EN81-ETC(U)
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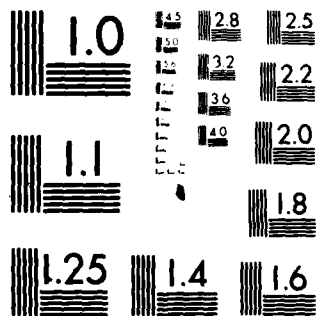
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IN-CYLINDER SAMPLING OF HYDROCARBONS IN A TEXACO
L-141 TCP ENGINE

FINAL REPORT

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IN-CYLINDER SAMPLING OF HYDROCARBONS IN A
TEXACO L-141 TCP ENGINE

FORWARD

The authors wish to thank the U.S. Army Research Office for providing the funding for this research. Thanks are due as well to the ATAC for providing the engine and to Martin Alperstein at the Texaco Research Center for sound guidance during the formative stages of this project.

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STATEMENT OF THE PROBLEM

The objectives of this study were to get an insight of where the hydrocarbons are formed in the L-141 engine.

Hydrocarbon emissions from direct injected stratified charge (DISC) engines present a serious obstacle to the widespread use of these engines in light to medium duty applications. Potential in-cylinder origins of these emissions appear to exist throughout the displacement volume. This report is a condensation of (1) M.C. Ingham's PhD thesis and (2) SAE Paper 820361. Readers interested in the details of the L-141 engine modifications, gas sampling system, method of analysis and the findings of the study should refer to the SAE Paper given as reference (2).

The Summary and Conclusions have been abstracted verbatim (reference 2) as given here.

FINDINGS, SUMMARY AND CONCLUSIONS

In-cylinder gas sampling experiments were conducted on a single-cylinder Texaco L-141 TCP stratified charge engine run at constant speed. Time- and spatially-resolved species data were obtained from three regions within the displacement volume of the cylinder using apparatus designed to reciprocate the sampling valve axially in accordance with piston motion. The purpose of these experiments was to study the effects of engine load on the axial distribution of fuel and products of combustion within the cylinder. Particular emphasis was placed on determining the in-cylinder origins and formation mechanisms responsible for the engine's exhaust hydrocarbon emissions.

The sampling apparatus developed for this study proved to be at least conditionally reliable. Rapid deterioration of the mating faces at the tip of the sampling valve was a recurrent problem at the deepest valve insertion used in these experiments. More durable materials are required for the tip construction before greater sampling depths can be achieved.

The fluid motion model, while admittedly imperfect, provided useful insight into the various factors which interact to determine the sample gas origins. The model makes it clear that, if we are to continue to use sampling valves to study combustion phenomena in high-swirl combustion chambers, significant improvements in valve actuation times will have to be made to achieve the required spatial resolution.

The following conclusions were derived from the results of this study:

1. The viability of obtaining gas sampling data from within the swept volume of a fired engine cylinder has been demonstrated.

2. Axial stratification is evident in the cylinder throughout the portion of the cycle sampled. The rather gradual rate of mixing suggests that the gases in the central core of the chamber do in fact rotate as a solid body.

3. Two of the three expected sources of hydrocarbons have been identified in the cylinder. The effects of conventional wall quenching were observed near the cylinder head surface at all loads. Unreacted fuel was observed to emanate from the combustion chamber bowl throughout the cycle. The exact source of this fuel appears to be vaporization from the deposit layer at the point where the fuel spray impinges. Lean flammability limit quenching was not observed but may still be an important hydrocarbon source in regions of the chamber not sampled in this study.

4. The high proportion of unreacted fuel observed in the exhaust at the 0.2 MPa IMEP load confirms the importance of the bowl surface source. This proportion decreases with increasing load because of the higher rates of fuel decomposition and destruction resulting from higher combustion temperatures.

5. The apparent contradiction between the axial gradients of fuel and products of combustion observed at the end of the compression stroke results from the squish-induced recirculation set up in the bowl as the piston approaches the cylinder head.

BIBLIOGRAPHY

1. M. C. Ingham, "In-Cylinder Sampling of Hydrocarbons in the Texaco L-141 TCP Stratified Charge Engine." Ph.D. Thesis, University of Wisconsin-Madison, 1981.
2. M. C. Ingham, P. S. Myers, O. A. Uyehara, "In-Cylinder Sampling of Hydrocarbons in a Texaco L-141 TCP Engine." SAE Paper No. 820361, 1982.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A technique was developed to obtain time- and spatially-resolved gas samples from the displacement volume of a reciprocating engine. The technique was used to investigate the distribution of fuel and products of combustion, with emphasis on the sources and formation mechanisms of gaseous hydrocarbons, in a single-cylinder Texaco L-141 TCP engine. A mathematical model predicted the actual sample gas origin, relative to the instantaneous sampling orifice position, as a function of the local gas motion and properties. (Con't.)		

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20. ABSTRACT CONTINUED

Linkage was designed to reciprocate a sampling valve along an axial path within the cylinder in accordance with piston motion. The linkage is adjustable such that the ratio of sampling valve to piston travel can be varied in steps from 1:3 to 1:1. The sampling valve insertion depth at top dead center is adjustable between zero and 25.0 millimeters.

→ Samples were taken at times ranging from 30^{deg} CA BTDC to 60^{deg} CA ATDC. Gas chromatography gave the sample composition, including the concentration versus carbon number distribution of the hydrocarbons. Local stoichiometry, local reactant hydrogen/carbon ratio and apparent local particulate concentration were also calculated.

Significant vertical stratification persists in the L-141 TCP combustion chamber as late as 60^{deg} CA ATDC, indicating that mixing in the vertical direction in the central part of the chamber is inhibited by solid body rotation of the gases.

Two of three potential sources of hydrocarbons were identified. Wall quenching at the cylinder head surface was recognized through the frozen hydrocarbon composition found in this region after 15^{deg} CA. High concentrations of fuel (heptane) found at all sampling locations prior to fuel injection were associated with a source of fuel on the bowl surface, located at the point of fuel spray impingement.

* Exhaust hydrocarbons consisted primarily of heptane, probably originating from the bowl surface, and species having two carbon atoms. Total hydrocarbons and the relative proportion of heptane to C₂ species decreased with increasing load, because of the higher gas temperatures.

A seeming contradiction in the vertical gradients of carbon dioxide and heptane found in the bowl prior to fuel injection is explained in terms of a squish-induced recirculating flow pattern.

